NASA Facts

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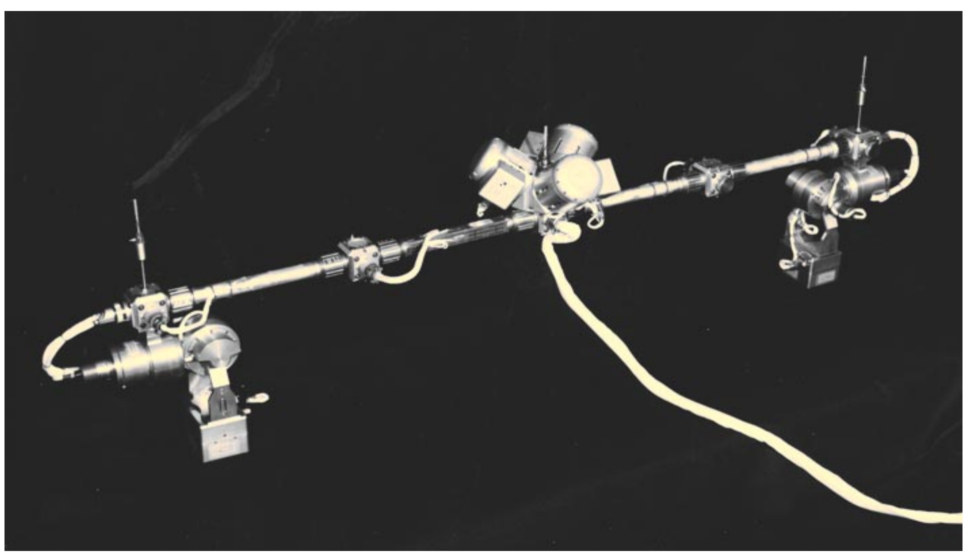
Building Structures in Space

As America's space program enters the 21st century, new missions of exploration and discovery are envisioned. Hubble telescope images of deep space, for example, have excited not only astrophysicists but the public as well. They want to know more about what may be in neighboring solar systems. Others want to understand Earth's changing atmosphere and find that the unique perspective from space is the only way to get a complete picture. The development of spacecraft and instruments to support these missions is the everyday work of researchers at NASA Langley Research Center.

Important to this development are advances in structures — the platforms upon which many missions depend. While focus has been on large in-space "truss" platforms for large mirrors and telescopes, the need has shifted to developing smaller, more affordable and higher precision structures designed for deep-space missions. What lies ahead for engineers at NASA Langley is perhaps one of their most exciting challenges — to broaden their understanding of how things move and work in space.

Middeck Active Control Experiment (MACE).

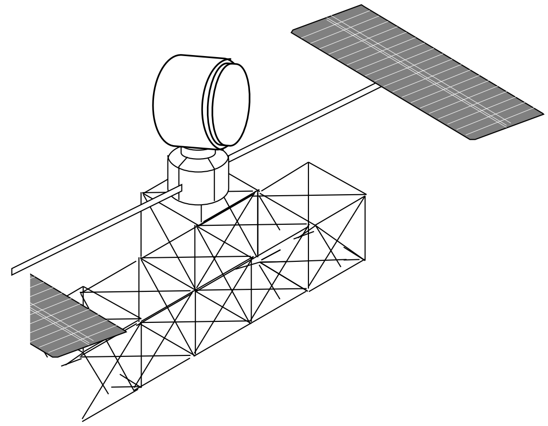
MACE is designed to study how certain components behave in space and how they affect other components and the structure itself — how spacecraft payloads affect each other and their supporting structure(s). Attachments to spacecraft, such as solar instruments on long booms or environmental sensors that scan back and forth, can cause small vibrations. These vibrations can move from one end of the spacecraft to the other, causing sensitive instruments to be misaligned and long booms to bow and bend. If these vibrations can be limited, spacecraft will not need heavy, expensive, rigid structures but can use flexible ones — even unmanned, deployable platforms.



The MACE test platform: The device pictured on the right side of the MACE platform simulates a satellite instrument which scans and points. The device on the left side simulates an instrument which is used to point at a precise location on the Earth.

MACE used the environment of the space shuttle (STS-67) to study how to actively control flexible structures in space and minimize the effects payloads and spacecraft structures have on each other.

The technology developed from the MACE data can be used to improve the stability of both Earth-monitoring satellites and astronomical instruments, such as telescopes. This technology is already being applied to suppress vibration in computer disk drive heads, control noise, isolate sensitive instruments and aid precision machining. MACE technology can also be used to reduce the vibrations in the space shuttle robotic arm, which often vibrates after being moved.



Concept of next generation gamma ray telescope and NASA Langley high-precision deployable structure.

High Precision = Four Millionths Of An Inch

Another major application for NASA Langley's research on space structures lies in a priority project for NASA called ORIGINS. ORIGINS came about in 1995 when scientists announced their discovery of two planets outside our solar system, both possibly capable of supporting life. The prospects of finding organic material on these planets has raised many questions about the kind of life, how advanced it may be and how scientists could know for sure. Using current technology, which can sense certain meaningful clues about an Earth-like atmosphere, scientists can only make inferences about what is there. Their instruments do not yet have enough resolution to see the new planets. What everyone wants now is a closer look.

NASA Langley is involved in designing the space structure for use specifically on the ORIGINS project.

NASA Langley's assignment has been to produce a high-precision platform, not larger than the launch vehicle on which it will travel. This structure will deploy unassisted to support a new telescope. The next generation gamma ray telescope will be three times larger than the current instrument on the Hubble telescope and, because of its size, will be made in sections which will be mounted on the NASA Langley structure. Because of the telescope's precision requirements, the supporting structure must be deployed, get into position and remain fixed and steady within an accuracy of four millionths of an inch. (Typically deployable structures require only low precision, varying three to four thousandths of an inch.) The design for the high-precision structure must be accomplished within the next decade.

Where to Begin

NASA Langley must first develop certain preliminary technology in order to begin building its deep space structure. Because the structure must be accurate to four millionths of an inch, researchers must first find a way to measure very accurately, thus expanding the science of measurement. Scientists will use laser and optical systems along with time measurement techniques. Once a device is available for such near molecular-size measurements, NASA Langley will design a structure which can be sectioned with hinges and unfold into position with consistent accuracy.

What is 1,000,00th of an inch?

1,000,000th of an inch is like . . .

. . . a goldfish compared to a whale
. . . 17 minutes out of 32 years
. . . one penny out of 10,000 dollars

New Materials

The study of structural responses, new mechanisms and components will naturally lead to the need for new, advanced materials. Even the most highly polished piece of metal has inconsistencies and points of friction which appear under a microscope and which would not meet the criteria to support deep-space high precision. A microscopic trough or groove at a joint could cause hinges not to seat correctly. Or if a platform's component is made of an environmentally sensitive metal, the component could change its shape or strength in harsh space conditions.

The Design

With the technology and proper materials in place, scientists can begin to concentrate on the structure's design. The current plan is to develop a structure which will unfold after it is released into space, positioning itself according to specifications. Once a prototype is fabricated, scientists can analyze it and test its structural integrity, deployment precision and dependable accuracy. If it passes many tests, including in-space hours and a series of redeployments, the final step is to find an efficient system for manufacturing it. The whole project must be cost effective.

Development of new materials brings the next generation of space technology closer.

New materials must meet several criteria:

Dimensional Stability. A dimensionally stable material retains its size and shape with changes in temperature. This is especially important in a spacecraft or structure which may orbit Earth, moving in and out of the sun's heat.

Light Weight. It takes ten pounds of resources to get one pound into space and back. Therefore, the lighter the material, the less costly it is to the mission.

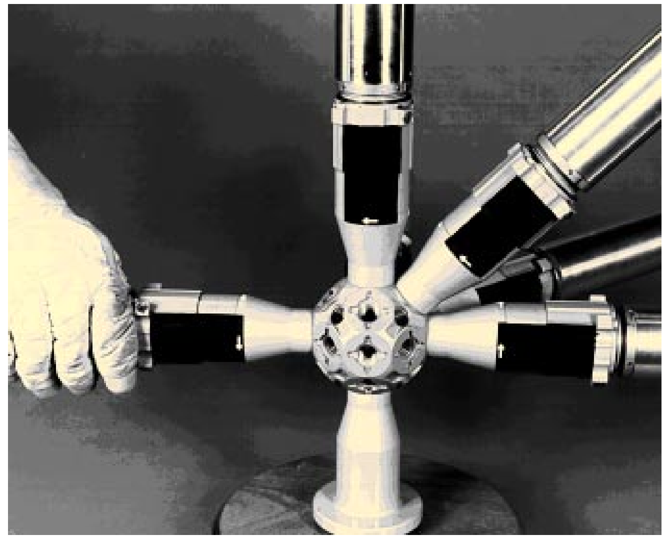
Environmental Stability and Durability. Most components must be durable in the harsh space environment, which includes radiation, atomic oxygen and a vacuum.

Strength/Stiffness. How much load a material can hold before breaking and how flexible it is are two different considerations determined by the desired application.

Manufacturability. A material that is hazardous to the people who are manufacturing it or to the environment can be more expensive to make because of the special requirements to handle and dispose of it.

Cost Effectiveness. The cost of a material, including production and testing, is a major consideration and can be the determining factor in whether or not it is used.

Structural experiments and testing were performed underwater because this approximated the weightlessness of space.



This precision node and strut joint was developed for one-handed assembly in space.

Other Structural Achievements

While NASA Langley has concentrated its efforts in recent years on the in-space assembly of high-precision deployable instruments, a decade ago the task was to design and build much larger structures for possible integration into the space station program. Because of their size, these structures were not designed to be placed in orbit in an operational state but to be assembled by astronauts in space during space walks.

NASA Langley's concentration on in-space assembly included joint hardware and quick-attach components. From their research, NASA Langley engineers developed two critical technologies. Their first was a quick-attachment joint for high-performance structures which astronauts have used aboard the space shuttle. The joints allow one-handed operation through spring-load latch bolts, and a tapered tongue-and-groove design eliminates free play. Numerically controlled machining has made it possible to fabricate joint hardware which gives consistent repeatable performance.

The second technology produced an efficient system for manufacturing precision trusses.

The earlier work of NASA Langley scientists has enabled them to predict the reactions of structures in deployment and thus establish their course as they participate in programs like MACE and ORIGINS. Large or small, the design and fabrication of space structures is a springboard for many near- and deep-space missions. In the years to come, NASA Langley will make new views of our universe possible and help launch us into an exciting future.

For more information contact:

Office of Public Affairs
Mail Stop 115
NASA Langley Research Center
Hampton, VA 23681-0001
(757) 864-6123
http://www.larc.nasa.gov/org/pao